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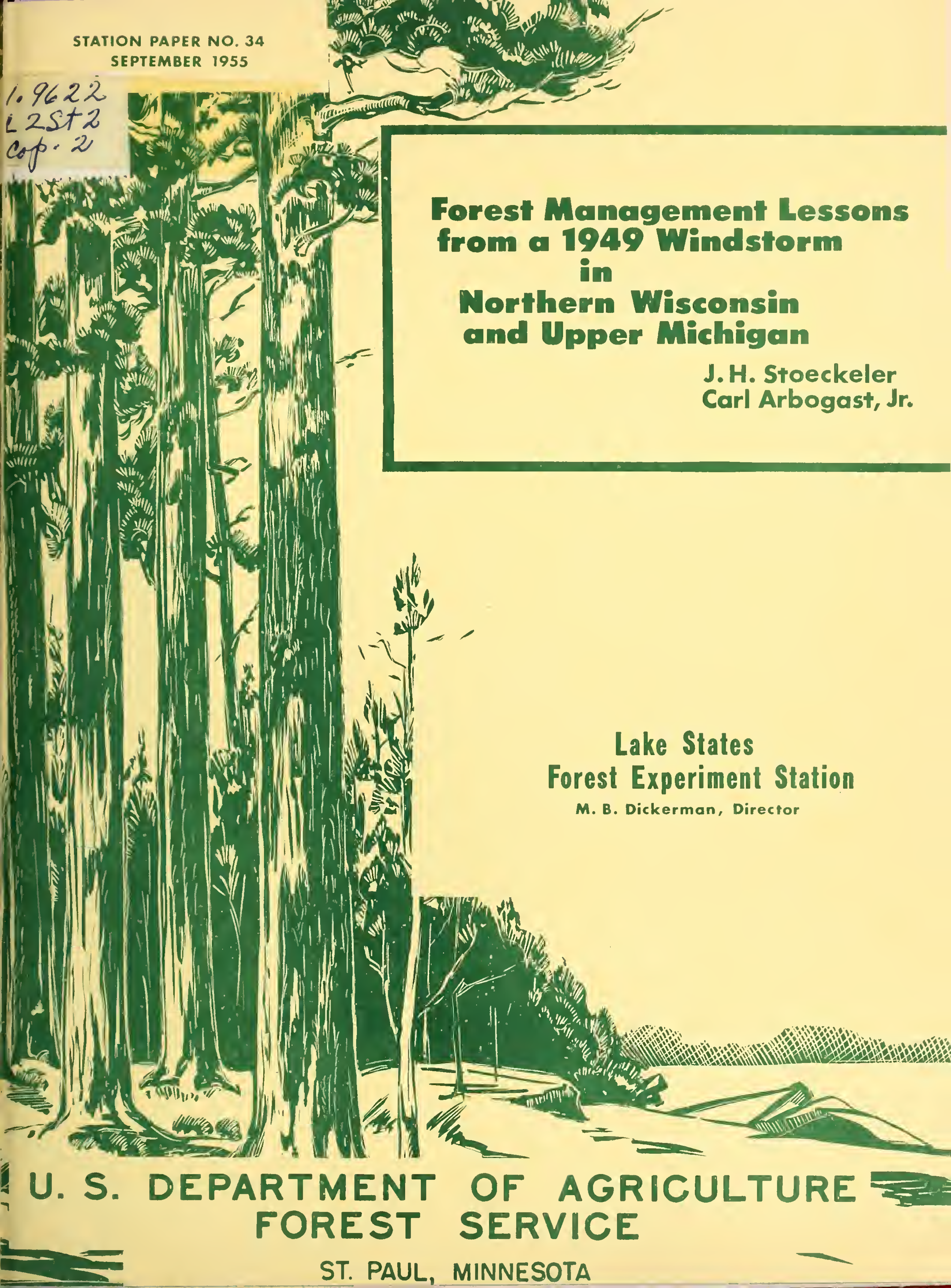

Forest Management Lessons from a 1949 Windstorm in Northern Wisconsin and Upper Michigan

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U. S. DEPARTMENT OF AGRICULTURE
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INTRODUCTION

On October 10, 1949, an unusually severe windstorm struck Wisconsin and the western half of the Upper Peninsula of Michigan. It caused heavy damage to the forests by uprooting, breaking, splitting, or tipping trees. Windstorms such as this inflict unpredictable losses in the forest and upset management plans, especially calculations of allowable cut.

With some storms, such as the September 1938 hurricane which struck the New England States, tremendous damage results and probably few, if any, practical lessons can be learned about modifying forestry practices to materially reduce damage that might be caused in the future by other windstorms. The windstorm of October 10, 1949, was not in this class but was mild enough to provide an opportunity for an overall survey. The conclusions drawn from this survey have certain practical applications for the manager of forest lands, especially where timber marking guides and policies are concerned.

According to Weather Bureau reports [2] recorded wind velocities ranged as high as 50 to 76 miles per hour. Unverified reports indicated wind velocities in localized areas up to 102 miles per hour in gusts. The wind was largely from the southwest. From the available records, it appears that in Wisconsin and Upper Michigan windstorms in excess of 50 miles per hour may occur about once every 20 to 25 years.

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[1] Maintained at St. Paul 1, Minnesota, in cooperation with the University of Minnesota.

[2] U. S. Weather Bureau. Climatological Data, Wisconsin 54: 153-167. 1949.

All sections of Wisconsin sustained damage, but it was worst in the northern and northwestern parts of the state. Larger sized timber was damaged extensively and so were overmature or defective trees and trees in exposed positions. Fortunately, most of the broadleaf species were already partially or completely devoid of leaves, so the damage to them was at a minimum. The conifer species, however, suffered rather heavily.

Reconnaissance for blowdown was done from airplanes, by car, and on foot. Inspection showed the damage to be quite spotty--patches of timber blown down where gusts of wind struck them in exposed positions such as on south and west slopes, swamp margins, and ridges, and along the north and northeast shores of lakes or rivers. Salvage operations were started immediately and continued for 2 years.

In connection with the scouting of areas of storm-damaged trees for salvage purposes on the three national forests affected, it was possible to record on a sample basis the amount of damage to different tree species by diameter, age, crown class, soil type, topographic position, slope, and exposure. The nature of the damage was also noted.

GENERAL APPRAISAL OF THE DAMAGE

It is estimated on the basis of rather accurate salvage records on three national forests that the storm blowdown for some 15 million acres of forest land in northern Wisconsin and the western half of the Upper Peninsula of Michigan was about 205 million board feet of timber, valued at one and one-half million dollars. Fortunately, a fairly good percentage was harvested as salvage on national, state, and industrial forests. The presence of a fairly intensive network of improved logging roads as well as old non-maintained roads built 30 or more years ago was a prime factor in a rather thorough salvage operation. The percent of timber salvaged on some classes of private holdings is believed to be much lower because of absentee ownership or lack of systematic salvage reconnaissance by the forest landowners. All told, about half of the 205 million board feet of timber was salvaged. In some instances as little as 200 board feet or about one-half cord per acre were picked up. A special stumpage rate of only one-half the usual minimum was an added inducement to loggers to clean up areas of low volume per acre of blowdown.

Some specific examples of salvage on forest areas of varying size are available. The overall timber salvage for 2.3 million acres in three national forests was 21,879,000 board feet, which was sold for a total of $160,611 (table 1). The 3.4 million board feet on the Nicolet National Forest is estimated to represent about 75 percent of all the blowdown which occurred on that Forest, the remainder being too inaccessible or too scattered to salvage.

Table 1.--Total and per-acre volume and value of timber salvaged on three national forests in Wisconsin and Michigan following the windstorm of October 10, 1949

National Forest	Net area	Volume salvaged	Value of salvaged timber	Per-acre volume salvaged	Per-acre value of salvaged timber
	Acres	Board feet	Dollars	Board feet	Cents
Nicolet	627,693	3,400,000	34,000	5.4	5.4
Chequamegon	825,325	8,890,000	69,077	10.8	8.4
Ottawa	849,848	9,589,000	57,534	11.3	6.8
Total or average	2,302,866	21,879,000	160,611	9.5	7.0

On the Chequamegon National Forest, the blowdown volume by species was: balsam fir 47 percent, hemlock 41, spruce 9, and white pine 3. On the Ottawa National Forest it was: hemlock 60 percent, spruce and balsam fir 27, pine 5, hardwoods 5, aspen and paper birch 2, and white cedar 1.

On a privately owned tract of 271 acres, mostly old-growth northern hemlock and hardwood, the blowdown was 9,600 board feet which was sold for $250. Per-acre averages were 35.4 board feet and 92.2 cents.

Some individual patches of timber suffered even more heavily, ocularly estimated in the range of 1,000 to 2,000 board feet per acre, valued at $20 to $40 per acre. For example, the Ahonen Lumber Company of Ironwood, Michigan, reported salvaging 6,714,000 board feet on two tracts, totaling 6,120 acres. Per-acre average was about 1,100 board feet, or $22.40 stumpage value. This was in old-growth hemlock-hardwood type. Hemlock constituted 71 percent of the entire volume salvaged. The cut probably included some of the standing timber which was not heavily damaged by the storm but was needed to make an economically feasible operation.

The low average volume losses per acre on large tracts comprising several hundred thousands of acres, as compared with the much higher losses on selected small tracts, indicate one of the reasons why it is difficult to predict growth and mortality for small tracts. Wind damage is spotty both because of variations in wind intensity and because of greater exposure to wind in some areas than in others due to topographic variations in the terrain.

DAMAGE IN INDIVIDUAL FOREST TYPES

The Argonne Experimental Forest is a rather typical northern Wisconsin forest tract of 6,500 acres consisting of 46 percent second-growth northern hardwood type, 34 percent mixed conifer swamp, 8 percent aspen-birch-balsam type, and 12 percent of combined other types. The total amount of wood salvaged in a rather intensive campaign was 11,790 board feet and 523.8 cords, with a stumpage value of $1,714, equivalent to 26.4 cents per acre. An estimated 90 percent of all the down timber was salvaged; the only part missed was so scattered that it was not economically feasible to pick it up. Volume by species salvaged during the first year is as follows: balsam fir 68 percent, black and white spruces 22, white pine 3, and hemlock 7.

Detailed figures and observations were taken in the various forest types to determine some of the practices forest managers could follow to reduce the possible damage from windstorms.

Hemlock-Hardwood Type

The heaviest damage recorded anywhere on the Argonne Experimental Forest occurred on a 30-acre tract of hemlock-hardwood type. Average volume salvaged was 315 board feet and 0.07 cord per acre, or a stumpage value of $4.13. Average volume per acre on the tract was 9,990 board feet. Hence, 3.2 percent of the original stand was blown down. Annual growth in this stand is estimated at 100 board feet per acre, so the storm removed about 3 years' growth. Of the sawlog material salvaged, 55 percent of the volume was hemlock, 33 percent white pine, 6 percent white spruce, and 6 percent other species.

The chief cause of damage to the 105 trees blown down on the area and the distribution of blowdown by species are shown in the following tabulation:

Species	Percent of blowdown by species	Chief cause of loss
Hemlock	60	Uprooting of shallow-rooted trees.
Balsam fir	20	Breakage caused by basal defect such as heart rot brought on by overmaturity. Two-thirds of trees lost were 8 inches or more in d.b.h.
White-cedar	8	Breakage caused by basal defect such as heart rot brought on by overmaturity.
White spruce	6	Uprooting or breakage of tall superdominants 3/ (mainly on swamp borders) because of exposed position.
Other species	6	White pines lightning-struck, or broken due to internal rot. Hardwood trees broken, usually at heights above 15 feet, because of yellow rot or other fungi which had weakened the central stem.

Based on these observations, superdominant hemlock and spruce, especially if within 75 feet of the margin of swamps, should be marked for cutting. So too should white pine that has internal rot. White pine, however, seems very wind-firm even when of superdominant crown class. Hardwoods, at least in second-growth stands devoid of leaves, also appear to be very wind-firm.

The presence of black ash on flats or on slight swales in upland areas denotes poor drainage and shallow rooting where large-crowned superdominants of all species are especially susceptible to windthrow. In such situations the maintenance of an even height of crown canopy appears essential to minimize storm damage.

3/ Trees extending considerably above the general crown canopy, sometimes called head dominants.

Selectively Logged Second-Growth Hardwoods

Loss per acre was much reduced in second-growth hardwood stands given an improvement cut a few years previous to the storm. In January 1950, an appraisal was made of relative windstorm damage in such tracts. This survey consisted of a 100-percent tally of all blowdown on 120 chains (7,920 feet) of line to a width of 1 chain on each side of the boundary between the cut (spring 1949) and uncut stands. This represented 12 acres in each condition. Volume before cutting was 3,690 board feet per acre and of this some 1,367 board feet were cut on the selectively logged area. The blowdown per acre on the uncut area was about eight times as much, both in numbers of trees and volume, as on the selectively logged area (table 2). Loss in terms of value per acre was about eight times as high in the uncut as in the logged area. The border effect of the light cut was deemed negligible in regard to storm loss in the uncut stand.

Table 2.--Comparative storm loss in uncut second-growth northern hardwoods and in similar stands given an improvement cut before the storm Argonne Experimental Forest, Wisconsin

Type of area	Loss in volume per acre			Stumpage value per acre[2]		
	Pulpwood	Sawlogs	Total[1]	Pulpwood	Sawlogs	Total
	Cords	Board feet	Board feet	Cents	Cents	Cents
Partially cut	0.021	3.6	14.1	6.3	3.6	9.9
Uncut	.184	26.9	118.9	61.5	20.2	81.7

[1] Cords converted to board feet at ratio of 2 cords per M board feet.
[2] Stumpage values are based on 1949-50 rates for individual species on the Argonne Experimental Forest.

In the uncut area, over half of the economic loss was in the balsam fir (47 cents per acre) included in the hardwood type, and most of the remainder in hemlock (21 cents per acre). In the selectively cut area, practically all the balsam fir that was mature and the high-risk hemlock were removed in the previous season's logging; hence, combined losses in these two species were reduced from 68 to 6 cents per acre, or 91 percent, by proper marking.

Based on observations in second-growth hardwoods handled on a 15-year cutting cycle, one should remove practically all defective trees with rot or canker, all wolf trees, forked trees, exposed superdominants, and most of the balsam fir judged to be 50 years old or older and 8 inches or more in diameter at breast height.

Balsam Fir Type

The balsam fir type had some of the heaviest damage of any of the forest types on the Argonne Experimental Forest, especially on rolling terrain with exposed ridges 20 to 40 feet high. Losses as high as 4 to 5 cords per acre were sustained on patches of several acres in size.

Of the balsam fir trees lost, 64 percent showed rot in the base of the bole, indicating overmaturity. Seventy-three percent of all the balsam fir lost were 8 inches in diameter or larger at breast height; these were estimated to be generally 50 years of age or older. Of the wind-damaged trees, 42 percent showed external evidence of defect such as basal frost cracks, rot, scars, woodpecker holes, or lumpy, pitchy, protruding knots.

Of the white-cedar lost, 89 percent were uprooted, and the bulk of the loss occurred in the form of 5- to 10-inch-diameter trees being pulled over by the uprooting of larger trees. Practically all of the larger sized white-cedar lost were those uprooted on the margins of swamps.

Of the few black spruce lost in the balsam fir type, most were broken off. Black spruce in the balsam fir type appears to be a high risk tree to leave when over 11 inches in diameter at breast height or over 70 years of age.

Comparatively few white spruce in association with balsam fir were damaged, and these invariably were superdominants rising considerably above the average crown canopy level. Of the white spruce damaged, 72 percent were broken off usually at 1 to 3 feet above ground; 56 percent were 15 inches in d.b.h. or over.

Conifer Swamp Type

Loss from the windstorm was less within the swamp type than on swamp margins or exposed upland ridges. This is probably due to the tendency for trees in the swamps to tilt somewhat under wind pressure and to resume their former position because of the springy nature of the peat and moss. On swamp margins the peat was only about a foot deep, often underlaid by a virtual pavement of "cobblestones;" here trees were very subject to windthrow.

In conifer swamps, 58 percent of the loss recorded was by uprooting, and an additional 16 percent was root-sprung. The remaining 26 percent of the damaged trees were broken. Altogether, about two-thirds of the loss was attributed to shallow rooting or superdominant crown position.

Balsam fir was the species most susceptible to loss and constituted 79 percent of all the recorded damaged trees in the swamp type. Of the balsam fir which went down, 73 percent were 8 inches or larger in diameter.

In one case study of swamp margins, 88 percent of the trees lost were balsam fir, of which 50 percent were uprooted and the remainder were broken. Eighty-eight percent of the blowdown balsam fir were 8 inches or larger in diameter and 75 percent were 9 inches or over. Large northern white-cedar, generally 15 inches or more in d.b.h., accounted for the remaining 12 percent lost.

In another case study on a swamp edge where species other than balsam fir were recorded by type of damage, it was noted that 70 percent of the trees had been uprooted and 30 percent broken off, usually at 1 to 3 feet above ground. Seventy percent of these uprooted or broken trees were 10 inches or over in d.b.h.

Of the white-cedar lost, mostly by uprooting, 62 percent were 10 inches or larger in diameter at breast height. The damaged tamarack in swamps were uprooted trees which averaged about 14 to 15 inches in diameter. Smaller and younger tamarack were singularly free of loss.

Aspen Type

Aspen showed rather minor damage by the windstorm. In a 100-percent tally of all mortality on a 20-acre tract of aspen from 4 to 8 inches in diameter, only 29 trees had been lost and of these, 27--or 93 percent--had broken off between 7 and 20 feet above ground at places on the stem infected with Hypoxylon canker. In older age classes of aspen, losses were slightly higher.

Pine Types

Damage in pine types was quite variable. Young stands suffered minor damage. Thrifty stands nearing maturity suffered somewhat more damage. Heavy damage was noted in overmature jack pine stands. Of the three species, jack pine suffered most, red pine was intermediate, and white pine had the least damage.

In a tract of about 120 acres of jack pine - red pine type, mostly 60 to 70 years old, there was over twice as much damage in jack pine as in red pine. Of 50 damaged pines examined in this stand, 40 percent were broken off at heights of 1 to 25 feet, 38 percent were uprooted, and 22 percent were root-sprung. Of the damaged jack pine, 45 percent were broken and 33 percent uprooted. Of the damaged red pine, only 12 percent were broken and 63 percent uprooted. Of the broken trees, 75 percent had internal rot at the point of breakage.

In the overall assignment of causes of damage in this jack pine - red pine stand, 30 percent was due to internal rot, 28 percent was attributed to the tree being excessively exposed, usually on the southwest slopes on the windward side of ridges or hills, 6 percent was ascribed to superdominant crown position, 4 percent was due to lack of root anchorage on one side, 2 percent was caused by shallow rooting, and 30 percent could not be attributed to any apparent physical or other defect.

White pine proved to be very wind-firm on upland soils and even trees of superdominant crown position, with tops 20 to 30 feet above the general level of the main stand crown canopy, stood the storm well. Such white pines as went down were usually on swamp or bog edges where depth of rooting was limited. Breakage occurred occasionally in overmature trees with internal defect.

The chief lesson taught by the storm in pine types was to harvest the stands when mature. Specifically, in unmanaged jack pine in northern Wisconsin on medium to good site, this maturity appears to be at about age 50 to 55. Also, any trees showing signs of internal defect as evidenced by woodpecker holes, cankers, and fire scars, are high-risk trees which suffer heavy mortality in windstorms.

DAMAGE TO TIMBER ON LAKE FRONTAGE

Damage to timber on lake frontage was severe, especially on the north or northeast side of lakes where the full force of the southwest wind uprooted the trees. Large-crowned trees were particularly susceptible. Pines and hemlock over 12 inches in diameter, especially those within 5 to 10 feet of the water's edge, suffered heavy casualties.

A survey of damage on a 500-foot stretch of south-facing lake frontage revealed that within 5 feet of the water's edge 56 trees were uprooted or broken off; 64 percent of the 45 conifers standing within 5 feet of the water's edge before the storm were uprooted or broken off. Practically all of the loss was due to uprooting, and most of the trees were red or white pines. The larger ones were 12 to 17 inches in diameter at breast height, and when these tipped over with a huge "pancake" of soil about 8 feet in diameter and a foot or more thick, they brought down with them smaller trees.

From general observations of wind damage on lake front properties it would appear that any large-crowned trees, especially pine or hemlock over 12 inches in diameter, require at least 8 to 10 feet of root anchorage on all sides to be reasonably safe from windthrow; those in the 6- to 11-inch diameter class need at least 5 feet to make them reasonably safe against uprooting.

SUMMARY

1. The windstorm of October 10, 1949, blew down about 205 million board feet of timber with a stumpage value of one and one-half million dollars in the forests of northern Wisconsin and the western half of the Upper Peninsula of Michigan.

2. Losses were especially heavy on exposed south and southwest slopes, swamp margins, ridges, and the exposed north and northeast shores of lakes and streams.

3. Except in small areas of heavy blowdown, the damage was more economic than silvicultural as most of the downed trees were overmature or defective.

4. A detailed survey uncovered certain criteria by which the forest manager can judge the wind resistance of individual trees in a stand. These are as follows:

   Hemlock-hardwood type.--Hemlock sustained the heaviest damage in this type, followed in order by balsam fir, white-cedar, white spruce, and white pine. The northern hardwood species such as sugar maple, yellow birch, basswood, white ash, and American elm showed little damage. Most of the hemlock and white spruce that were damaged were situated on flat areas along swamp margins or in swales. Superdominant white spruce, balsam fir, hemlock, or white pine on flats within 75 feet of the swamp edges are poor wind risks. The maintenance of an even height of crown canopy on flats and swales on upland areas, where the presence of black ash indicates poor drainage and shallow rooting, appears essential to minimize storm damage.

   Second-growth hardwood type.--The damage in this type was confined mostly to the coniferous species, 58 percent of the economic loss being in balsam fir, 26 percent in hemlock, and the remainder in defective hardwoods. Improvement cutting in this type substantially reduces the danger of wind damage. To be effective, the cut should remove all defective trees with serious rot or canker, wolf trees, forked trees (especially when there is a swelling at the fork), exposed superdominants, and all balsam fir judged to be 50 years old or older and 8 inches or more in diameter at breast height.

Balsam fir type.--Balsam firs 8 inches and over in diameter at breast height and 50 years or older are highly susceptible to windthrow. Only 42 percent of the windthrown balsam fir examined showed external evidence of defect. Size and exposure are the most important criteria in judging wind resistance of this species.

Conifer swamp type.--Loss from the windstorm was less in the swamp type than on the swamp margins. In the swamps the trees of all conifer species most susceptible of loss were any with basal defect or superdominant crown position and balsam fir over 8 inches in diameter at breast height. On swamp margins and shallow areas within the swamps where the peat is only 1 foot or less in depth and underlaid by rock, cobblestone, and boulders, the trees of all species were especially subject to windthrow. To maintain a wind-firm stand in this situation, cutting should be very light and confined to removing the superdominant and defective trees, or the area should be clear cut.

Aspen type.--Damage in this type was negligible, being confined mostly to trees infected with Hypoxylon cankers.

Pine types.--Losses were heaviest in jack pine, intermediate in red pine, and least in white pine. Overmature jack pine showed especially heavy damage as did jack pine with signs of internal rot, canker, and fire scars. On medium sites, there appears to be no alternative except to clear cut jack pine stands 60 to 70 years of age. In white or red pine stands, cuttings made at 10-year intervals should largely eliminate the high-risk trees, thereby keeping windstorm losses to a minimum.

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